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Attorney's Docket No.: 774-010704-US(PAR)

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): LAM et al.  
Serial No.: 10/006,752  
Filed: 11/08/01  
For: AN OPTICAL COUPLING MOUNT

Group No.:

Examiner:

Commissioner of Patents  
Washington, D.C. 20231

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Application Number : 0122425.2  
Filing Date : September 17, 2001

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1. Your reference

PJF01215GB

17 SEP 2001

2. Patent application number

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0122425.2

18SEP01 E660549-1 002890  
P01/7700 0.00-0122425.2

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Nanyang Technological University  
School of Electrical & Electronic  
Engineering  
Block S2, Nanyang Avenue  
Singapore 639798

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

8227704001

4. Title of the invention

AN OPTICAL COUPLING MOUNT

5. Name of your agent (if you have one)

Gill Jennings & Every

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Broadgate House  
7 Eldon Street  
London  
EC2M 7LH

Patents ADP number (if you know it)

745002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
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Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
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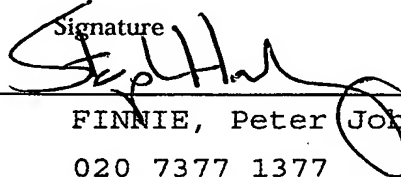
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Request for preliminary examination and search (Patents Form 9/77)	0
Request for substantive examination (Patents Form 10/77)	0
Any other documents (please specify)	NO

11. For the applicant  
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature  


Date  
17 September 2001

12. Name and daytime telephone number of person to contact in the United Kingdom

FINNIE, Peter John  
020 7377 1377

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## AN OPTICAL COUPLING MOUNT

### Background to the Invention

5 There is a great need to couple efficiently the light between a semiconductor edge emitting waveguide device and a single mode optical fibre. In order to achieve significant coupling, it is often necessary to convert the small and severely astigmatic optical mode profile obtained from a semiconductor waveguide device such as a ridge-guided laser, a modulator or a semiconductor optical amplifier, to the concentric and larger modal profile of a single mode fibre. Typically, this modal mismatch results in a coupling loss of  
10 between 8 and 10 dB.

Current approaches for achieving such coupling are threefold: (a) employment of a micro-lens system between the device and the fibre, (b) use of a converter fibre, such as a graded refractive index (GRIN) fibre, at the tip of the single mode fibre, and (c) incorporation of a spot size converter with the semiconductor substrate i.e. monolithically  
15 integrate the spot size converter and semiconductor laser. The disadvantages of method (a) are those of high cost and complexity of alignment and mounting, of method (b) are those of instability and tight alignment tolerance and of method (c) are the potentially lower device yield resulting from the increased processing difficulties and the added cost of the III-V semiconductor material. In addition, all the above-mentioned approaches  
20 suffer from a misalignment problem associated with coupling single mode devices, whereby a 1 dB decrease in coupling efficiency can result for a lateral misalignment of less than  $\pm 0.5\mu\text{m}$ .

### Summary of the Invention

25 According to one aspect of the present invention, an optical bench for coupling light between an optical device and an optical fibre, the optical bench comprising an integral optical spot size converter and optical alignment means for fixing the position of an initially separate optical device relative to the optical spot size converter so that, in use, light is coupled between the optical device and the optical spot size converter.

30 In the present invention, we provide an optical bench upon which is located an optical spot size converter and provision for alignment and mounting of a separately formed optical device such that on assembly the spot size converter is in close alignment with the optical device. Accordingly, the present invention provides a simple means for

waveguide. The spot-size at the output facet of the converter, for the design simulated, yielded an 88% modal distribution matching with a single mode fibre and with a high mode conversion efficiency of 97%.

5 Figure 5 shows the calculated variation in coupling loss with vertical misalignment at the input facet of the spot size converter for three different sizes of ridge laser. The results illustrate that where ridge lasers of width between 3 and 5  $\mu\text{m}$  are considered, it is determined that a misalignment of 0.3  $\mu\text{m}$  would result in a loss of less than 2 dB.

10 Figure 6 shows the calculated variation in coupling loss with lateral misalignment at the input facet, for the simulations considered in Figure 5. Here the results illustrate that a loss of less than 3dB can be achieved for a misalignment of less than 1.75  $\mu\text{m}$ , which is comparable to other semiconductor monolithically integrated spot-size converters.

15 Figure 7 shows the provision of a v-groove 30 in the optical bench 31 which can aid in the alignment of an optical fibre 32 when, for instance, butt-coupled to the output facet 33 of the spot size converter 34. Also shown is a semiconductor waveguide device (ridge laser) 35 which provides the input light to the spot size converter 34. Figure 8 is plan view of Figure 7 and shows the relative positioning, on the optical bench 40, of the optical fibre 41, semiconductor waveguide device 42 and spot size converter 43, including the lower waveguide 44 and upper waveguide 45 of the spot size converter 43. Also shown are the aids to alignment including: the v-groove 46, the trench 47, the alignment grooves 20 48 and some additional alignment marks 49.

25 Figure 9 shows a symmetrical variant of the embodiment illustrated in Figure 8 to provide for fibre to waveguide device to fibre coupling. Located on the optical bench 50 are the two optical fibres 51, the waveguide device to which they are to be coupled 52, and two spot size converters 53, including the lower waveguides 54 and upper waveguides 55 of the spot size converters 53. Also shown are the aids to alignment including: two v-grooves 56, a trench 57, alignment grooves 58 and some additional alignment marks 59. The embodiment shown in Figure 9 has many applications where the propagation of light in a fibre has to be interrupted for the purposes of amplification or modulation.

## CLAIMS

1. An optical bench for coupling light between an optical device and an optical fibre, the optical bench comprising an integral optical spot size converter and optical alignment  
5 means for fixing the position of an initially separate optical device relative to the optical spot size converter so that, in use, light is coupled between the optical device and the optical spot size converter.
2. An optical bench according to claim 1, formed of a silicon material.  
10
3. An optical bench according to claim 1 or claim 2, in which the spot size converter comprises a pair of waveguides, at least one of which is dimensioned so as to cause light preferentially to couple from one waveguide to the other as light propagates along the  
length of the waveguide.  
15
4. An optical bench according to any preceding claim, in which the spot size converter comprises an upper waveguide having a reducing lateral taper along at least part of its length, vertically spaced a distance above a non-tapering lower waveguide.
- 20 5. An optical bench according to claim 4, in which the upper waveguide and lower waveguide are separated by a cladding region.
6. An optical bench according to any preceding claim, in which the optical alignment means is adapted to receive the optical device.
- 25 7. An optical bench according to any preceding claim, in which the optical alignment means is keyed for engagement with the optical device.
8. An optical bench according to any preceding claim, in which the optical alignment  
30 means comprises at least one trench in the optical bench within which the optical device is to be located and one or more alignment grooves or ridges that cooperate with corresponding alignment ridges or grooves, respectively, formed on the optical device.
9. An optical bench according to any preceding claim, further comprising an integral

V-groove dimensioned to allow for the location of an optical fibre adjacent a facet of the spot size converter.

5 10. An optical assembly comprising an optical bench according to any preceding claim in combination with an optical device located on the optical bench, and an optical fibre, each of the optical device and the optical fibre being aligned with the spot size converter to provide coupling of light between the optical device and the optical fibre.

10 11. An optical assembly according to claim 10, in which the optical device is a semiconductor edge emitting waveguide device.

12. An optical bench or optical assembly substantially as shown in and/or described with reference to any of Figures 1 to 9 of the accompanying drawings.

15



**ABSTRACT**  
**AN OPTICAL COUPLING MOUNT**

5       An optical coupling mount for use in coupling light between a semiconductor  
waveguide device and an optical fibre comprises a silica based spot size converter (3)  
located on an optical bench (1) with a trench (8) and grooves (9), whereby the  
semiconductor device (2) can be positioned in close alignment with the spot size converter  
(3). The spot size converter (3) comprises a tapered upper waveguide (4) located above  
a non-tapered lower waveguide (6). The dimensions of the spot size converter (3) are  
10   such that a semiconductor device emitting a small, astigmatic optical beam can be  
efficiently coupled to a single mode fibre requiring a larger, concentric beam.

[Figure 1]

15

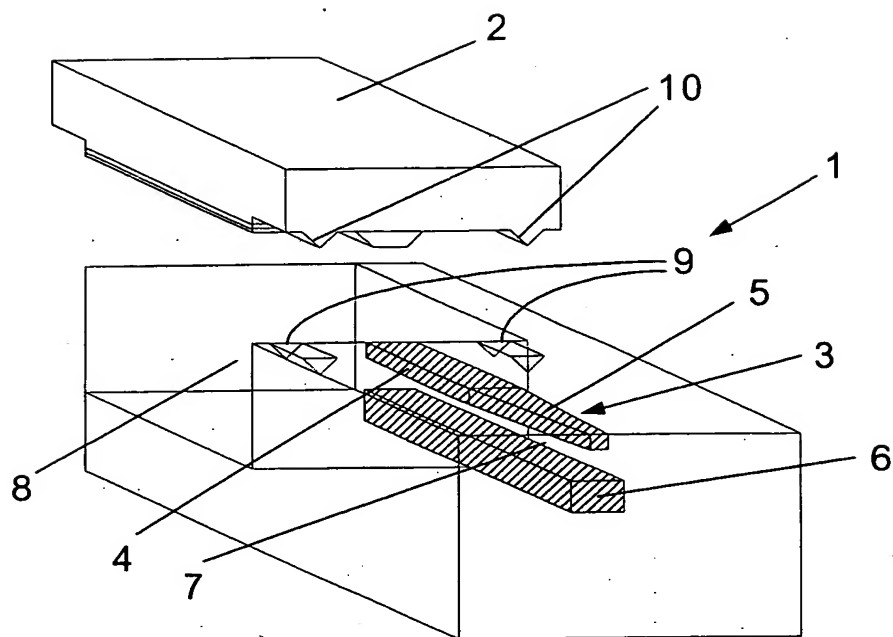


Figure 1

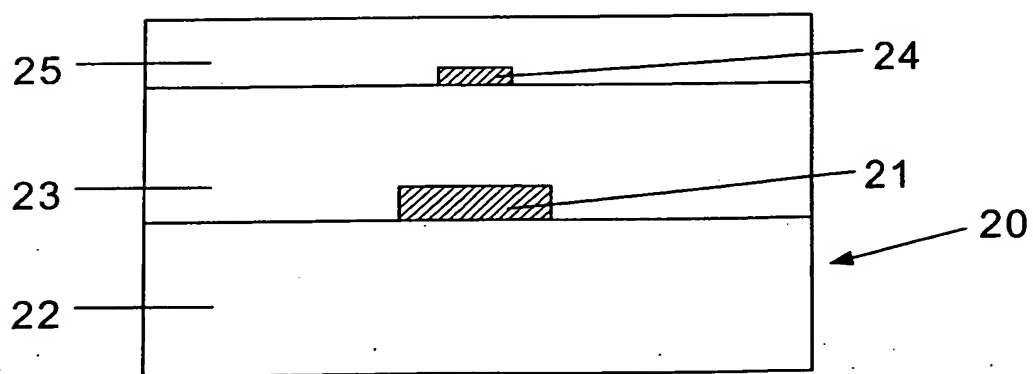


Figure 2

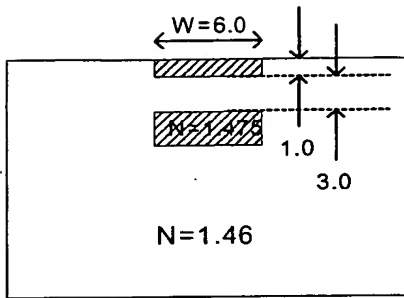


Figure 3A

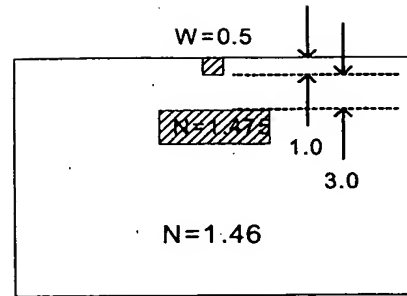


Figure 3B

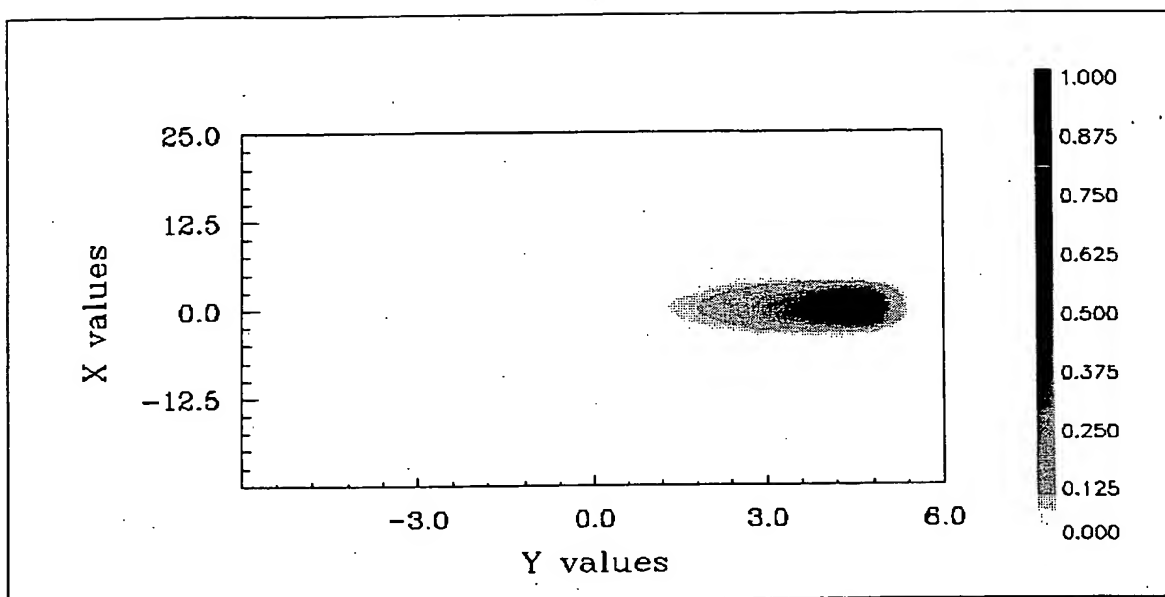


Figure 4A

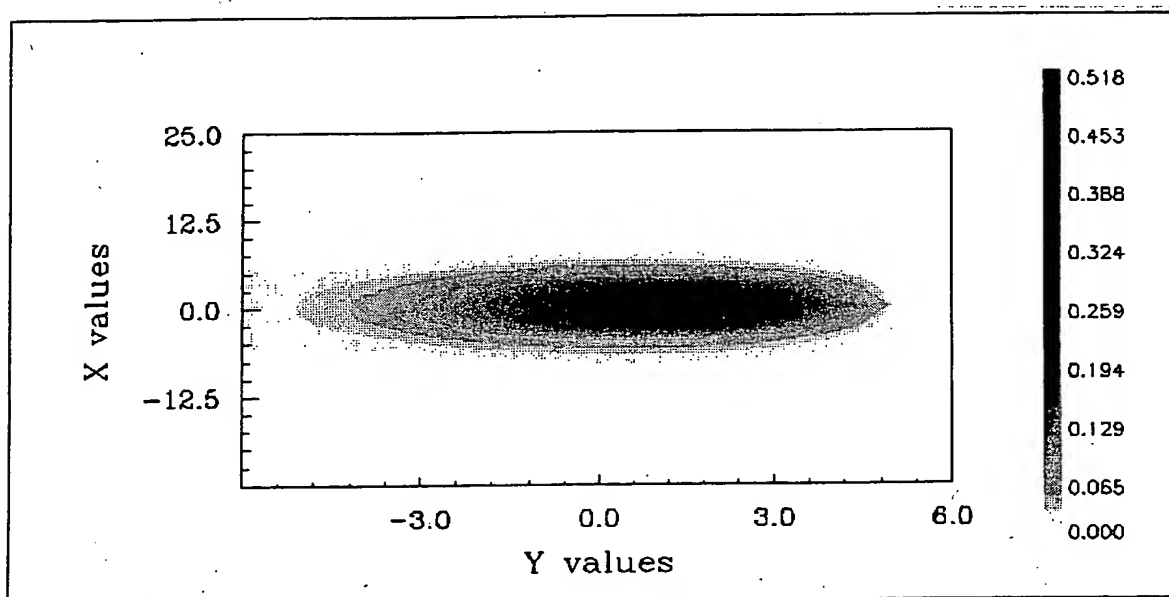


Figure 4B

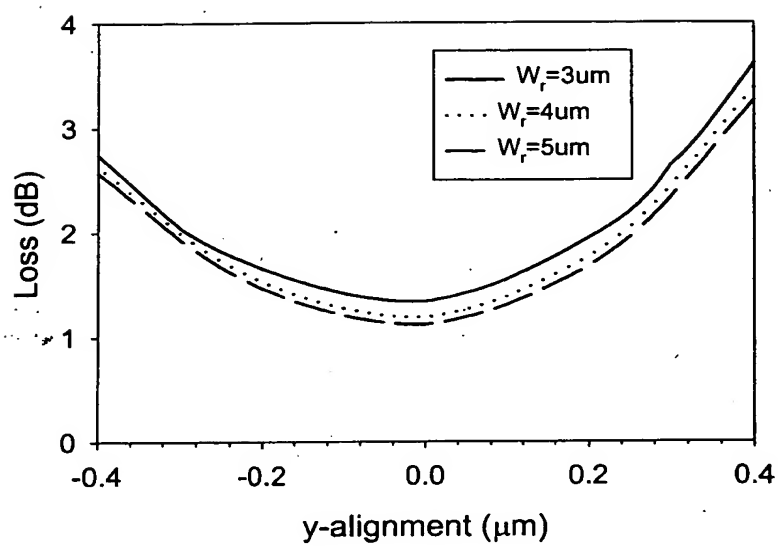


Figure 5

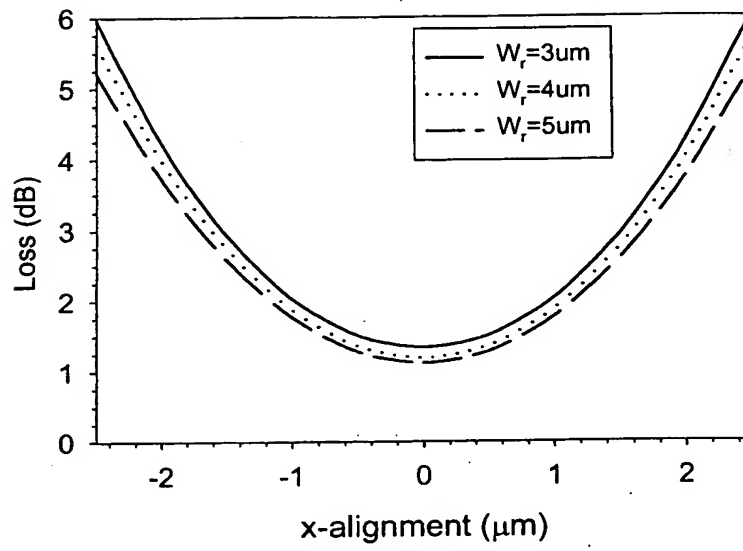


Figure 6

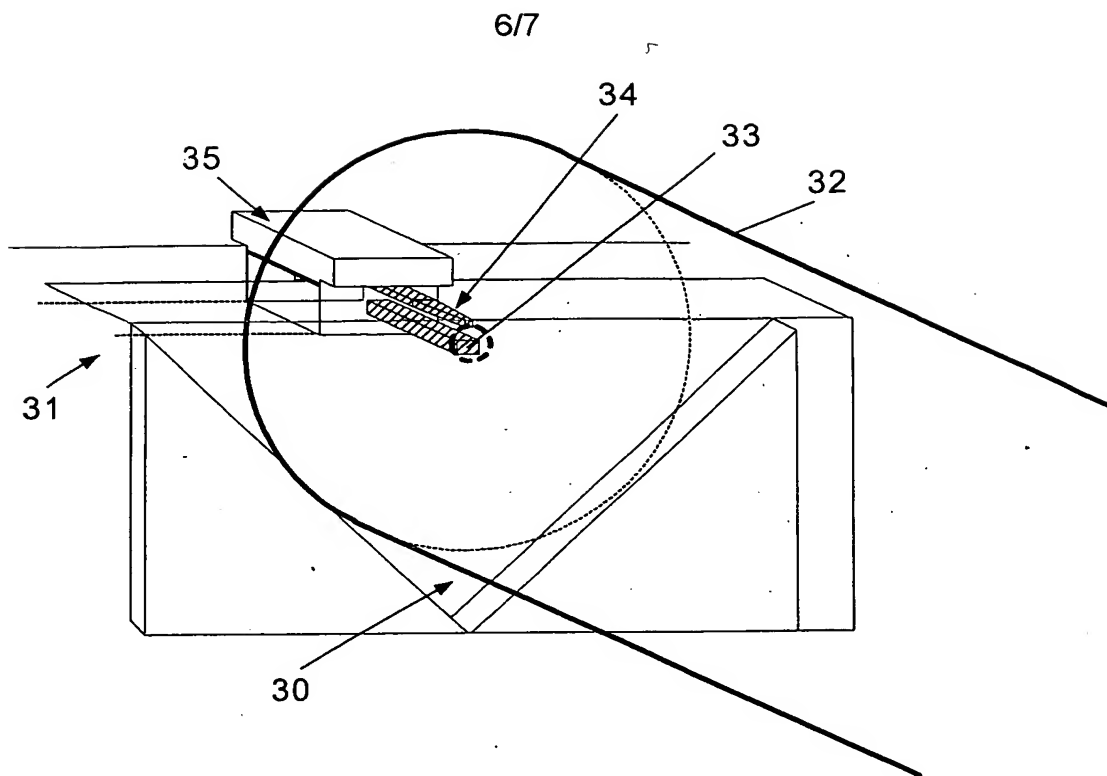


Figure 7

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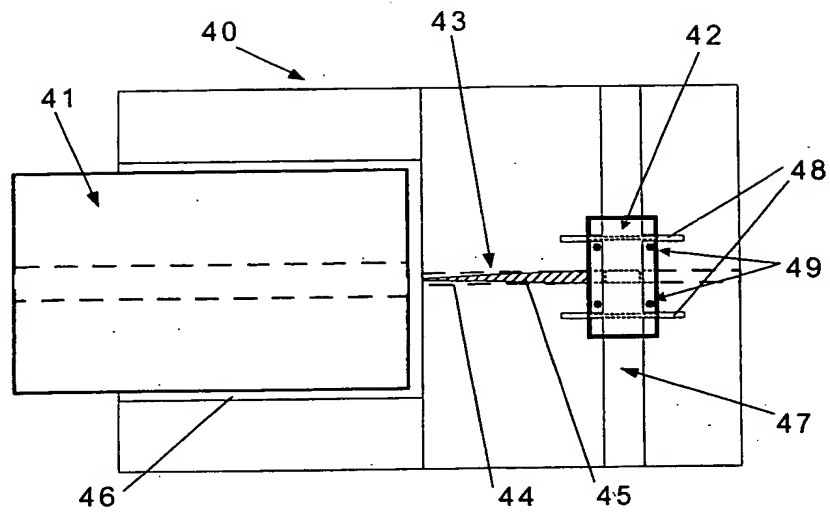


Figure 8

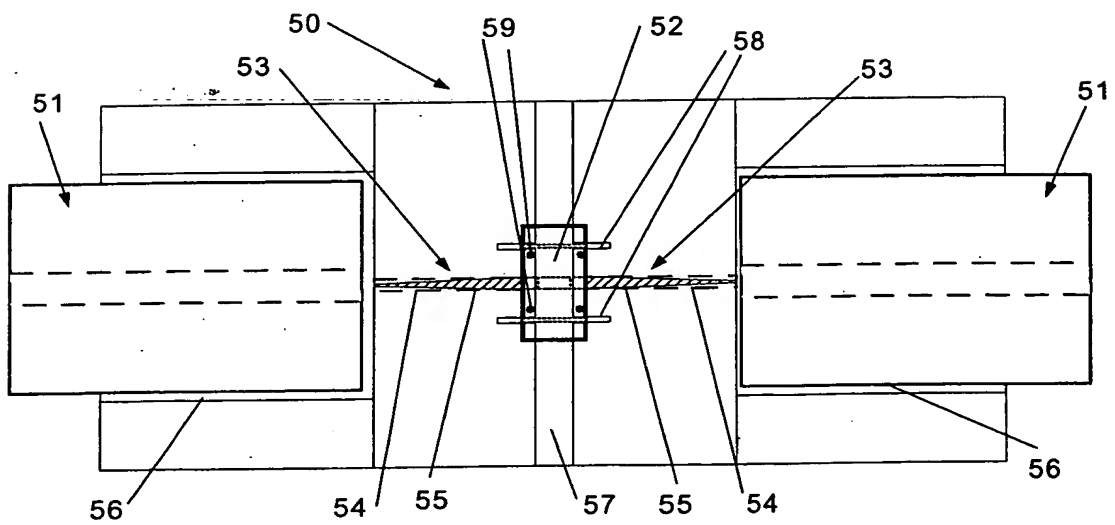


Figure 9